January I found the budgerygahs arrived in small numbers at 0520 hours. These built up until by 0715 hours I estimated 100,000 birds were over the dam. The birds continued to arrive all morning but by about 1400 hours the birds had finished drinking and moved off to feed. At all times the birds appeared little afraid of man and one individual landed on B. A. Y. Main and drank water from her filled palm. At the dam the birds usually hovered helicopter fashion while drinking, touching only with their beaks. However, some floated with wings outstretched while drinking.

Red-backed Kingfisher *(Halcyon pyrrhopygia)*. A nest of this bird was found in the bank of Goddard's Creek. Chicks called when I blew softly near the entrance. Since Lindgren and Slater also found this bird with young, it would appear to be independent of the presence of water for beginning the nesting cycle.

Little Crow *(Corvus bennetti)*. Although no specimens were taken strong wind blew up the feathers of live birds, exposing the bases which were white. Since the birds were smaller than the galahs I therefore placed them as this species. About 30 birds perched in trees surrounding the soak. Probably they would feed on exhausted budgerygahs.

Apart from these notes there is little other information to add on the bird species which would be additional to that provided by Slater and Lindgren.

I am indebted to R. G. Royce for the identification of the plants mentioned in the text.

TROPICAL CYCLONES AS BIOCLIMATIC ACTIVATORS: Part II

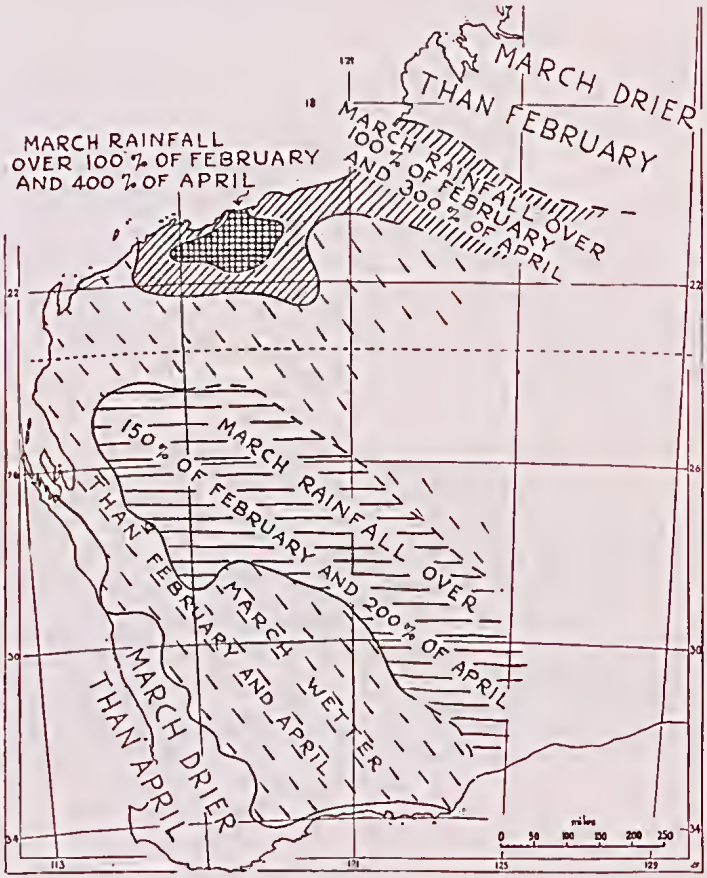
By J. GENTILLI, Nedlands

THE SPREADING OF MOISTURE

The increase in humidity associated with tropical cyclones has an immediate effect on some aspects of animal life. Gentilli (1949) recorded a definite correlation between relative humidity and the call of the Willy Wagtail *(Rhipidura leucophrys)* in the Perth Metropolitan Area. This call fluctuates sporadically during most of the year, and only becomes regularly recurring during the mating and nesting season, during which relative humidity is nearly always higher than the minimum amount required to stimulate the bird. During the mating and nesting season—winter and spring—frontal cyclones dominate the weather. Some unseasonable summer calls are due to the bird's response to humidity brought by tropical cyclones or by low-pressure troughs associated with them in the middle latitudes. On December 12, 1948, calling was quite general—and relative humidity stood at 69 per cent.

The cumulative effect of tropical cyclones is noticeable in the mean rainfall. Over a large area which corresponds to the greatest

frequeney of eyelonie traeks, the rainfall inereases from February to Mareh, to deerease again slightly in April (Map 1). Sinee the summer rainfall of many loealities in the wheat-belt is only one or two inehes, and the rainfall for February or Mareh perhaps 20 or 30 points, it takes only one tropieal eyelone bringing 400 points in 48 hours to raise the mean rainfall for the month by 5 points if the reeord goes baek 80 years, by 10 points if the reeord goes baek 40 years, ete. Normally May or June is the wettest month in the Eastern Goldfields, and yet beeause of the torrential downpours reeeived from a few tropieal eyelones in reeent years, the wettest month there is now Mareh.



Map 1. EFFECT OF TROPICAL CYCLONES ON THE AVERAGE RAINFALL.

The white areas show the normal rainfall pattern, with Mareh drier than February in the Kimberleys and Mareh drier than April in the South-West. In the shaded areas Mareh is wetter than February and April. Notiee the effeet of the Hamersley Range in sheltering the area immediately to the south.

CYCLONIC TRACKS

The area affected by tropical cyclones varies considerably, not so much because of variations in the size of cyclones, but because many of these cyclones cover a short track only and die out without ever reaching the middle latitudes. Some travel further but lose most of their identity. A few, e.g., only 7 out of 72 recorded since 1924, reach the southern shore of the continent without any apparent loss of intensity. Most of these cyclones, whether they cross the continent or whether they die out in the tropics, follow fairly regular tracks. They originate in the Timor Sea, usually between 10 and 15 degrees South, and travel south-westwards at a speed of 5 to 15 miles per hour. Between 20 and 25 degrees South they gradually recurve southwards and then southeastwards, so that some 4 out of 10 cross the coast between Onslow and Broome. Anomalous tracks are not rare, an outstanding example being provided by the cyclone of February-March, 1956, which first travelled almost due east from La Grange to a point north-east of Alice Springs, then almost reversed its course crossing the shore in a westward direction near Cape Leveque, gradually recurving and passing to the west of Fremantle, crossing the west coast between Mandurah and Bunbury, and passing out to sea again about 50 miles west of Albany. The exceptional length of the track, its coastal location, and the almost unabated force of the cyclone throughout make it quite outstanding.

The track of any tropical cyclone is a function of several variables, namely the rotation, intensity and size of the cyclone itself, the sphericity of the Earth and its angular velocity at the points concerned, and the surrounding meteorological conditions, with special regard to pressure and moisture. A very intense cyclone, i.e., one with a very low pressure at its centre, is likely to travel much farther than a cyclone of moderate intensity. A large cyclone travels farther than a small one, other things being equal. Tropical cyclones do not originate within 4 degrees South and North of the Equator, and probably not beyond 20 degrees North or South. The tracks which appear to originate at 22 or 24 degrees North or South almost certainly failed to be detected while they already existed in lower latitudes.

On the poleward side, tropical cyclones may travel so far as to merge with a middle-latitude depression, which they intensify considerably. Tropical cyclones can only travel around the large travelling anti-cyclones characteristic of the lower-middle latitudes; should a tropical cyclone meet an anti-cyclone head-on, it would be destroyed by the inflow of dry air at higher pressure. This *cyclolysis,* as it may be termed, is not rare between 22 and 26 degrees South, where cyclones may meet large anti-cyclones especially towards the end of the cyclonic season (late March, April). On the other hand, a cyclone may slide along the col of lower pressure between two anti-cyclones, where a stationary front usually occurs, and reach the middle latitudes without losing its identity, even though some of its characteristics may change. For example, no thermal fronts occur in tropical cyclones, but

while a tropical cyclone travels between two anti-cyclones, it is fed by different air-masses from the north-east and from the south-west, and whereas these two air-masses were similar enough to form only a stationary front between the two anti-cyclones, the large amounts of tropical air and the additional dynamic impulse supplied by the cyclone's rotation are enough to give rise to a definite point. If the cyclone works its way to middle high latitudes* it then becomes indistinguishable from the frontal cyclonic depressions characteristic of these latitudes. Only a few cyclones travel so far, and, as mentioned above, only 7 out of 72 recorded since 1924 actually reached the southern shore without any loss of intensity.

Every cyclone has an individuality of its own, and must be studied separately. In fact, the conditions which precede each cyclone should also be studied, but such a thorough approach is not practical at the present time. The most profitable way of studying cyclones is by taking a few typical ones as suitable examples. Thanks to the detailed records kept at the Perth Weather Bureau this study can be carried out at any time. Cyclones may be chosen according to any one of their characteristics, but in this case the emphasis shall be on the spreading of moisture. One could recognize three main types: (a) the cyclone which does not go beyond latitude 22° S., (b) the cyclone which ends somewhere between latitude 22° and 30° S., and (c) the cyclone which goes beyond latitude 30° S. For each main type there may be three varieties: oceanic, coastal, and continental, according to where the greater part of the track actually runs—a cyclone begins by being oceanic, and may become first coastal and then continental, or remain coastal, or remain oceanic throughout.

C. A. Juengling, assisted by D. M. Logue, has made a good study, here published for the first time, of the cyclones of the 1947-48 season, which happen to fall into each one of the three major types mentioned above, and all of which interest the continent.

THE TROPICAL CYCLONE OF DECEMBER 29 TO 31, 1947

On the morning of December 28, a cyclone of moderate intensity was located about 150 miles WNW of Broome. While it drifted on a SW course along the Kimberley coast, a trough of weak gradient formed over the Gascoynes, bringing the coastal divisions under a circulation of easterly to north-easterly winds. The rains at this early stage were almost negligible; Broome reported 2 pts., Derby also 2 pts.

In the morning of December 29, the isobaric pattern over the chart of 12 noon. Whereas the southward movement of the storm State had completely changed, as can be seen from the synoptic

* There are no observations of cyclones in these latitudes to the south of Western Australia, but there are several records of Western Australian tropical cyclones which have ultimately reached Tasmania as ordinary depressions, and detailed studies of similar occurrences have been made in New Zealand (Barnett, 1938) and in the United States (e.g., Knox, 1955).

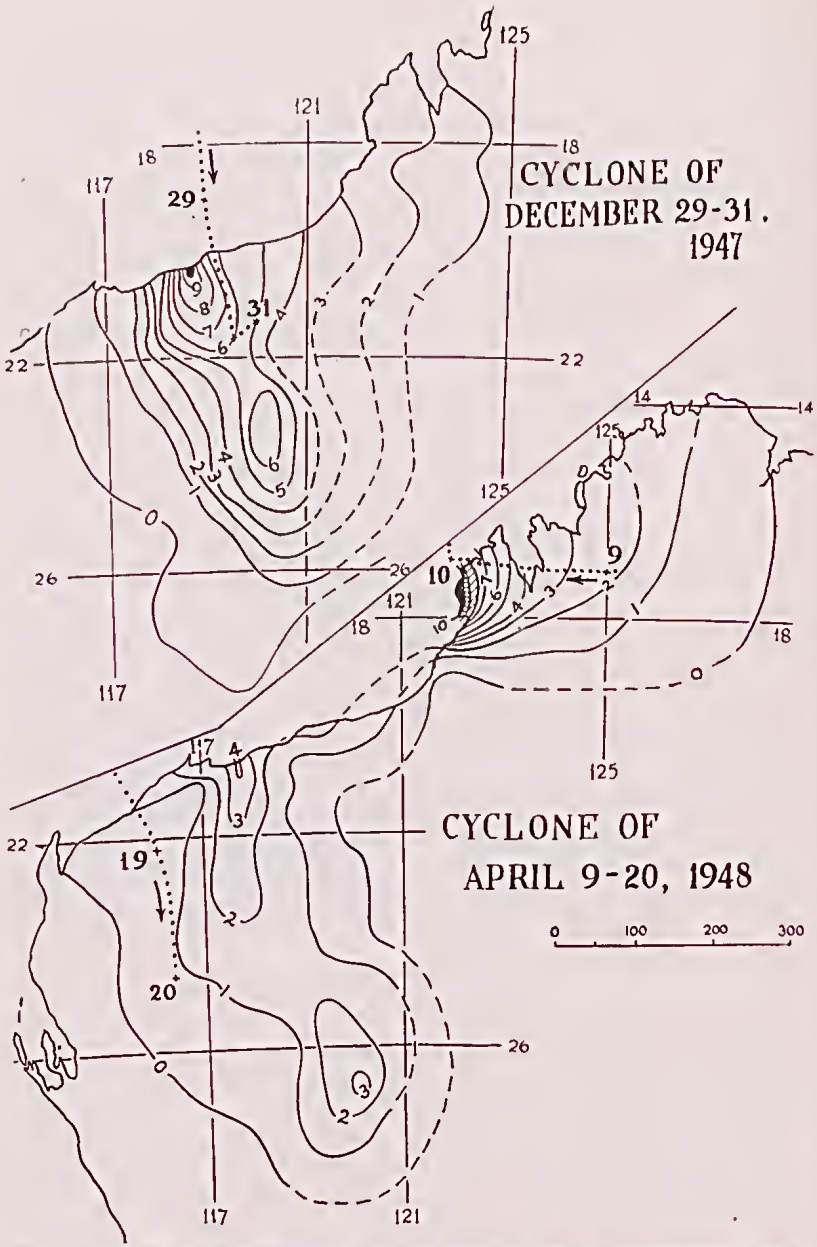
centre itself had been extremely slow, since the previous day the trough had been transformed into a well-defined "col" that also contained a "satellite" low. The col allowed the tropical cyclone to move inland and on that day the cyclonic disturbance caused unsettled, cloudy conditions as far as Eucla. The satellite low caused only isolated showers, but was also responsible for a severe thunderstorm and winds of 80 m.p.h. near Kalgoorlie. On the afternoon of this day the tropical cyclone was still 50 miles NE of Port Hedland. Although from its weak gradient and intensity it was estimated that the cyclone would die out within the first 24 hours after crossing the coast, its effect was nevertheless almost as strong as that of a young and active cyclone. Winds of over 80 m.p.h. were recorded from Cockatoo Island; Broome and Derby reported winds of 40 to 50 m.p.h. (with a maximum during the night). Several stations like De Grey, La Grange, Port Hedland and Anna Plains reported falls of more than 100 pts., and the rainfall area spread southwards beyond Marble Bar (75 pts).

By noon on December 30 the tropical cyclone had crossed the coast near Port Hedland and reached Marble Bar. Its further progress was doomed by a ridge of high pressure in the south which meanwhile had dissolved col and satellite low. In the last 24 hours torrential rains had fallen in the coastal region. The maximal registrations were 900 pts at Port Hedland (which received 1,023 pts in two days), 419 at Bonny Downs, 360 at Nullagine, 520 at De Grey, 509 Marble Bar. The rainfall area extended as far as Meekatharra (16 pts), Wiluna (50), Cue (4), but did not spread very far towards west and east, even Roebourne receiving only 16 pts. Some light showers were still recorded from the South-East Division. During the night a hurricane of 100 m.p.h. had caused some damage at Port Hedland; at Marble Bar it unroofed the Post Office and damaged other buildings. Gale-force winds continued to blow all day and were felt as far as Nullagine, 60 miles from Marble Bar; the heavy rains at Wiluna, however, were not associated with winds.

During the 31st, when the cyclone rapidly died out, the winds abated, even near its centre, and most of the coastal stations recorded only slight rainfalls, but stations near the centre, like Ethel Creek and Mundiwindi, were flooded by rains of over 400 pts.

THE TROPICAL CYCLONE OF FEBRUARY 19 TO 23, 1948

The February cyclone, one of the few cyclones that crossed the western half of the continent without losing their intensity, seems to have originated from a small "wave" in the inter-tropical front. The synoptic charts of February 16 and 17 still show the depression as being a part of the I.T.F. which at that time ran parallel to the West Kimberley coast, causing good rains in the tropics as far as Marble Bar (121 points on Feb. 16) and Ethel Creek (209 pts on Feb. 17). While the depression centre deepened (1002 mb at noon on Feb. 17) a trough of weak gradient yet considerable extension formed over the northern half of the State.



Maps 2 and 3. TROPICAL CYCLONES OF DECEMBER, 1947, AND APRIL, 1948.

These maps, after originals prepared by C. A. Juengling, show a cyclone which died out in the tropical area (above) and a cyclone which died out after entering the middle latitudes (below). The dotted lines show the paths of the cyclones, the larger figures the date of the month. Rainfall is given in inches, and is the total amount recorded as caused by the respective cyclone.

The deepening of the trough was presumably assisted by a low pressure tendeney due to aetive eonveetion over the heat eentre in the Pilbara region and, even more, by a low-pressure eentre off the south coast. The eorresponding centre of high pressure (south-west of Cape Leeuwin) of merely 1014 mb favoured the development rather than impeding it.

On February 18 eonveetional rains from weak thunderstorms conneeted with the trough and further frontal rains fell in the De Grey, Kimberley and Forteseue divisions. La Grange totalled 268 pts in 24 hours. At 3 p.m. while the depression centre was situated 300 miles WNW of Broome, falling pressure along the coast indieated further deepening. Even in the South-West Division an unusual rise in temperature was noticed due to the inflow of tropical air earried southwards by the expanding trough.

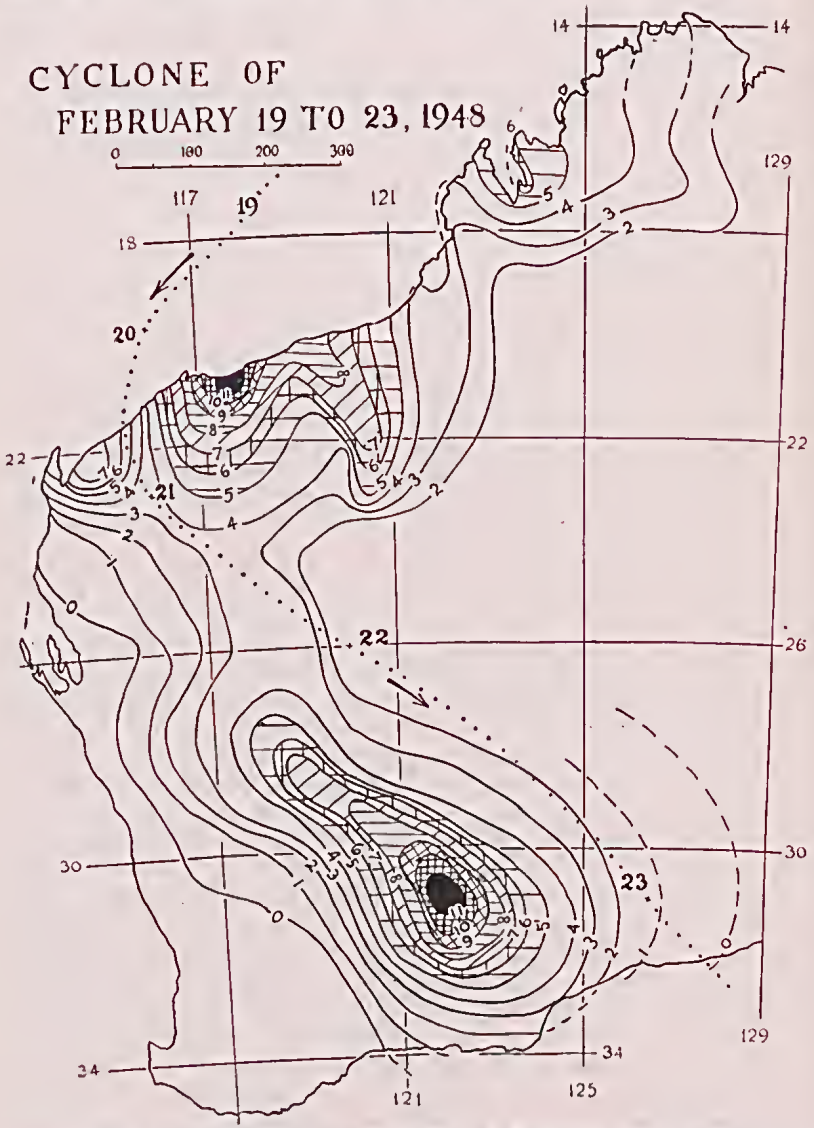
On the 12-noon ehart of February 19 a mature storm centre of less than 992 mb can be seen, surrounded by an almost elliptical pattern of isobars over the sea. The longer axis of the ellipses pointed roughly in the direction in whieh the eyelone was to advanee later on following the line of least resistanee. An E to NE eirculation of moderate to strong winds by that time covered most of the State. Stations near the eoast already reported gales of 40 to 50 miles per hour. Temperatures above normal and further rains—190 pts at Derby—ruled the day in the tropies and subtropies. The barometer continued to fall while the storm centre slowly drifted on a WSW course and at a distance of 300 miles along the coast. During the 24 hours from noon on February 19 to noon on February 20 the eyelone covered a distanee of about 220 miles.

At noon on February 20 the storm centre of now less than 986 mb was loeated only 80 miles northwest of Roebourne where, during the last 24 hours, the pressure had fallen from 998 mb to 991 mb. Generally speaking, the heaviest rains fell in the region elose to the storm centre wherever it passed; De Grey reported 500 pts. Port Hedland 352, Andover 500. At Roebourne where the day had begun with dust storms, 152 pts fell in the three hours from 9 a.m. to noon, followed by 666 pts in the 24 hours to come. The area east of the eyelone—the left-front quadrant to use Tannehill's terminology—due to moisture-laden centripetal winds blowing on-shore, received heavier rains at a given time than the eorresponding area in the right-front quadrant of the storm, e.g., Mardie (27 pts) and Onslow (84 pts). Likewise the winds were stronger on the on-shore side than on the off-shore side; their effeet was felt inland as far as Marble Bar and Nullagine.

When the tropical eyelone erossed the coast east of Onslow shortly before 3 a.m. on February 21 the town was hit by a storm of 72 m.p.h. and heavy rains. In general, these high winds rotating around the eentre somewhat abated, because of frietion with the land surfaee, when the eyelone advaneed inland. A remarkable feature was, for instance, that the Kalgoorlie rains on the 22nd and 23rd were not associated with winds at all. Big Bell, however,

and other places in its neighbourhood reported winds of over 50 m.p.h., unroofed buildings and uprooted trees.

As for the movements of the centre itself, since its recurvature from a WSW to an ESE course the cyclone was gaining speed while travelling on. The comparative distances travelled for each span of 24 hours ending at noon on the 21st, 22nd and 23rd were



Map 4. TROPICAL CYCLONE OF FEBRUARY, 1948.

The map, adapted from an original by C. A. Juengling, shows the path (dotted line, with dates in large figures) and the total rainfall (in inches) of a cyclone which left the tropical regions to enter the stream of westerly circulation south of Australia.

approximately 260, 330 and 540 miles. This again agrees with Tannehill's findings about the eyelones whieh eurve in at lat. 20° N and aeeelerate their movement on their way into the middle-latitudes.

On February 21, while many stations in the North-West—now well behind the storm eentre—continued to report falls of more than 100 pts (Andover 101, Ethel Creek 112, La Grange 321, Marble Bar 212), the rainfall area advaneed ahead of the travelling eyelone. Kathleen Valley, for example, which during the whole day was between 400 and 200 miles in front of the storm centre, had already totalled 50 pts, Sandstone 90 pts, and slight falls totalling 7 pts were reported from Laverton.

On February 22, while the tropical storm now eentred over the East Gaseoynes continued its SE movement, the total rainfall area extended from the De Grey to the Euela Divisions. At midday, when the centre was about to pass Wiluna and Meekatharra, rains set in in the Kalgoorlie district which were to continue almost without interruption till 3 p.m. on the following day. In the evening, when the eyclone approaehing Kalgoorlie was as elose as 200 miles, the rains were still described as being similar to good strong winter rains rather than "cloudbursts," but their intensity inereased when the eentre passed Kalgoorlie in the early morning, not far from Bulong whieh reeeived 1,135 pts. In the 21 hours between noon on the 22nd and 9 a.m. on the 23rd Kalgoorlie received 700 pts, the main part of its total of 1,200. Widgiemooltha and Narndie also reported over 10 inehes and many other stations in the region reeorded between 8 and 9 inehes.

At noon on February 23 the cyclone was centred near Rawlinna and when at 3 p.m. it crossed the eoast (not far from there) into the Bight the rains as well as the winds in the whole of the South-East Division were abating. The intensity of the former tropieal eyclone, which now went on as a normal middle-latitude eyclone, was still almost unchanged.

The pastoralists in the North-West praised the rains for their benefieial effect; they had provided excellent feed for the sheep. The rains had been heavy enough to make the Gascoyne River flow and reaeh Carnarvon, and to let the Coongo dam near Mt. Magnet overflow. On the other hand, the damage caused by the floods ran into many thousands of pounds. Even before the storm entered the continent, heavy downpours had soaked the airfields in the North-West, forcing planes to return, rendered roads and rivers impassable and left communities like Roebourne weather-bound for days. Lines of communication were disrupted everywhere in the North-West and the weather reports reached Perth many days late. The winds caused damage to houses and trees but did not cause loss of life. In the Kalgoorlie-Boulder area houses were flooded and railway lines washed away. At South Boulder a bridge on the main road to Perth collapsed. Sections of the Yalgoo-Wiluna line were 6ft. deep under water. On many lines, including the trans-continental, trains were stalled for several days and the Kalgoorlie

airport was not serviceable for 24 hours after the last rain had fallen.

Old residents of the area claimed this cyclone to have been the one with the longest uninterrupted rain they could remember.

THE TROPICAL CYCLONE OF APRIL 9 TO 20, 1948

This cyclone, according to local reports, was the first April cyclone for four years. Besides representing in this survey the cyclones near the end of the hurricane season, it is also an example of a weak cyclone which hovers over the sea off the Kimberley coast for many days, slowly advancing and retreating under the control of travelling anticyclones in the south. It appeared first on the synoptic charts of April 7 and 8, as a trough of tropical air expanding from a vast low of 1008 mb north of the Kimberleys. At this stage only light winds, light showers and general cloudiness were noticeable in that coastal part.

On April 9, while a high-pressure ridge stretched over the south of the State, a weak cyclone of 1004 mb had formed over the Derby area, giving rise to strong winds from all directions and rainfall as far as Fitzroy Crossing.

During the following days the cyclonic disturbance was forced to retreat when the anticyclone in the south intensified. Heavy rains fell on the Kimberley coast on April 11 when the cyclone was 150 miles north of Broome. The recordings for this day were 495 pts at Broome, 203 at Derby, 75 at La Grange and 63 at Hall's Creek. Less rainfall was recorded on April 12 and, from then on, only isolated falls until April 17. During these days the cyclone remained almost stationary, moving only a few miles per day on a zig-zag course. Yet, although the cyclone was blocked off the continent by the high-pressure cell in the south, it formed a trough (in the rear of this anticyclone) which extended along the west coast as far south as Perth. A satellite low in this trough, which had developed on April 13, dissolved again, but the trough still deepened while shifting eastwards and enabled the tropical cyclone to link up with a newly-arrived depression west of Busselton which also travelled eastwards.

On April 15 the trough extended from the De Greys to the northern Goldfields, causing slight rains near the coast and cloudiness over the remainder of the trough area. The intensity of the cyclone had varied all the time, sometimes with a deepening, but more often with a weakening tendency. The frontal system it had built up behind the vanishing anticyclone and in front of the next, allowed the cyclone to move slowly south-westwards to the coast. At 9 a.m. on April 18 it was centred about 200 miles north of Onslow, causing rains and cloudiness in the North-West Division; 27 hours later, at noon on April 19, the charts show that the centre had crossed the coast and was now located about 100 miles SE of Onslow. The cyclone itself brought rains as far south as Meekatharra, the frontal system connected with it brought rain to stations as far east as Earaheedy (180 pts). Cyclonic centre and frontal system were pushed northwards (and eastwards) on April 20 and

21, when a powerful antieyelone of more than 1032 mb passed south of Cape Leeuwin. The eyelone lingered on over the sea for some more days but did not eross the eoast again and its effeet was no longer felt.

The maps make it possible to give a rough estimate of the areas affeeted by the rainfall brought by these three eyelones. It will be seen that not only did the February, 1948, eyelone spread moisture over a mueh larger area than the other two eyelones eombined, but it also brought mueh heavier rainfall generally.

TABLE IV

RAINFALL BROUGHT BY CYCLONES IN THE 1947-48 SEASON

Rainfall Points	Dec. 28-31, 1947 sq. miles	Feb. 19-23, 1948 sq. miles	Apr. 9-20, 1948 sq. miles
0- 100	92,500	180,500	145,000
100- 200	50,500	97,000	80,000
200- 300	42,000	92,500	31,500
300- 400	19,000	90,000	6,500
400- 500	14,500	67,000	2,100
500- 600	11,500	44,000	1,700
600- 700	6,700	26,500	1,200
700- 800	3,000	23,000	800
800- 900	600	17,000	600
900-1000	——	7,500	400
1000-1100	——	6,000	——
1100	——	3,000	——
Total	240,300	654,000	269,800
Total acre/feet*	26,137,000	105,046,000	18,311,500
Aver. inches	2.05	3.03	1.28

The Deeember eyelone affeeted some 29,500 square miles less than the April eyelone, but it brought nearly 8,000,000 aere/feet more water, and spread an average of 2.05 inches over the whole area, against 1.28 inches brought by the April eyelone, and against 3.03 inches brought to 654,000 squares miles by the February eyelone.

A NEW SKINK FROM WEST KIMBERLEY

Egernia striolata douglasi ssp. nov.

by L. GLAUERT

Two skink speeimens eolleeted by Mr. A. M. Douglas at the Wotjulum Mission in West Kimberley are so eonsistently different from the known forms that they warrant deseription and naming.

Description

Head moderate, rather narrow, a groove behind the nostril, frontonasal in eontaet with the rostral, prefrontals in eontaet, frontal one and a half times longer than wide (6 mm. x 4 mm.),

* An aere/foot is the quantity of water needed to eover one aere of ground with one foot of water. This corresponds to 1,356 tons of water. Thus the February, 1948, eyelone dropped 142,442,376,000 tons of water over 654,000 square miles of land.